
Tissue paper and tissue products
Part 5:
Determination of wet tensile strength

Papier tissu et produits en tissu

Partie 5: Détermination de la résistance à la rupture par traction à l'état humide

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 12625-5 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 172, Pulp, paper and board, in collaboration with Technical Committee ISO/TC 6, *Paper, board and pulps*, Subcommittee SC 2, *Test methods and quality specifications for paper and board*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition cancels and replaces EN 12625-5:1999 which has been technically revised.

With regard to EN 12625-5:1999, the following changes have been made:

- a) addition of information concerning the precision of the test method;
- b) editorial updating.

ISO 12625 consists of the following parts, under the general title *Tissue paper and tissue products*:

- *Part 1: General guidance on terms*
- *Part 3: Determination of thickness, bulking thickness and apparent bulk density*
- *Part 4: Determination of tensile strength, stretch at break and tensile energy absorption*
- *Part 5: Determination of wet tensile strength*
- *Part 6: Determination of grammage*
- *Part 7: Determination of optical properties*
- *Part 8: Water absorption time and water absorption capacity, basket immersion test method*
- *Part 9: Determination of ball burst strength*

Tissue paper and tissue products

Part 5: Determination of wet tensile strength

1 Scope

This part of ISO 12625 specifies a test method for the determination of the wet tensile strength of tissue paper and tissue products after soaking with water, using a tensile-strength-testing apparatus operating with a constant rate of elongation.

Currently, two types of tensile-strength testers are commercially available: one where the test piece is positioned vertically and, for the other, horizontally. This part of ISO 12625 applies for both. For vertical tensile-strength testers, a device which is held in the lower grip of the tensile-strength tester, called a Finch Cup, is used to achieve the wetting. For horizontal tensile-strength testers, the soaking device is placed between the clamps.

It is expressly stated that the detection of impurities and contraries in tissue paper and tissue products should be applied according to ISO 15755.

For the determination of moisture content in tissue paper and tissue products, ISO 287 should be applied.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 186, *Paper and board — Sampling to determine average quality*

ISO 187, *Paper, board and pulps — Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples*

ISO 1924-2, *Paper and board — Determination of tensile properties — Part 2: Constant rate of elongation method*

ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

ISO 12625-1, *Tissue paper and tissue products — Part 1: General guidance on terms*

ISO 12625-4, *Tissue paper and tissue products — Part 4: Determination of tensile strength, stretch at break and tensile energy absorption*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12625-1 and the following apply.

3.1 wet tensile strength
maximum tensile force per unit width that a test piece soaked with water will withstand before breaking in a tensile test

NOTE The wet tensile strength is expressed in newtons per metre.

3.2 wet-tensile-strength retention
ratio, expressed as a percentage, of the tensile strength of the wet test piece to the tensile strength of the same test piece in the dry, conditioned state

4 Principle

A test piece of tissue paper or tissue product of given dimensions, soaked in water for a given period of time under specified conditions, is stretched (elongated) to break at a constant rate of elongation, using a tensile-strength-testing apparatus that measures and records the tensile force as a function of the elongation of the test piece.

The test can be carried out by a vertical or a horizontal tensile-strength tester.

In order to wet the test pieces for a vertical tensile-strength tester, a device, called a Finch Cup, which is held to the lower clamp, is used; while for a horizontal tensile-strength tester, a soaking cup is inserted between the clamps.

From the wet tensile strength and the tensile strength of the same sample in the dry conditioned state, the wet-tensile-strength retention can be calculated.

5 Apparatus

5.1 Vertical tensile-strength tester

5.1.1 Tensile-strength-testing apparatus

Tensile-strength-testing apparatus shall be in accordance with ISO 1924-2. It is capable of stretching a test piece of tissue paper or tissue product of given dimensions, at a constant rate of elongation of (50 ± 2) mm/min, and recording the tensile force as a function of elongation on a strip chart recorder or any equivalent device.

The force-measuring system shall measure loads with an accuracy of $\pm 1\%$ of the reading or $\pm 0,1$ N, whichever is the greater. It shall be calibrated and verified in accordance with the requirements of ISO 7500-1.

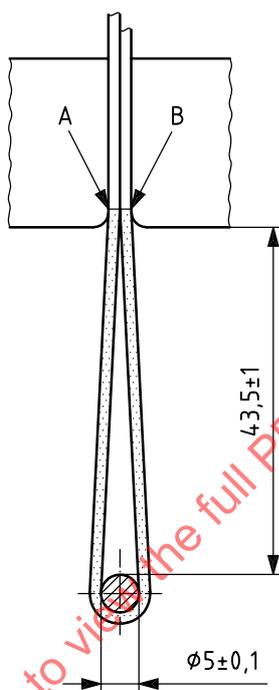
5.1.2 Tensile-tester clamps

The tensile-strength-testing apparatus (5.1.1) shall have an upper clamp with a minimum of 50 mm width, for holding both ends of the test piece firmly and without slippage. To avoid damaging the test pieces, the clamp surfaces that touch the pieces should be smooth and have rounded edges, i.e. free from burrs. The lower clamp shall be designed to grip the Finch Cup soaking device (5.1.3) firmly. The clamps shall have means for adjusting the clamping force.

During the test, the upper clamping line and the Finch Cup soaking device rod (5.1.3) shall be parallel to each other. They shall also be perpendicular to the direction of the applied tensile force and to the length axis of the test piece.

The test span length, which is defined as the distance between the clamping line and the top surface line of the cylindrical rod of the Finch Cup soaking device, shall be adjustable to ± 1 mm (see Figure 1).

Dimensions in millimetres



Key

\overline{AB} = (100 ± 2) mm
= total span length

$\frac{\overline{AB}}{2}$ = (50 ± 1) mm
= test span length

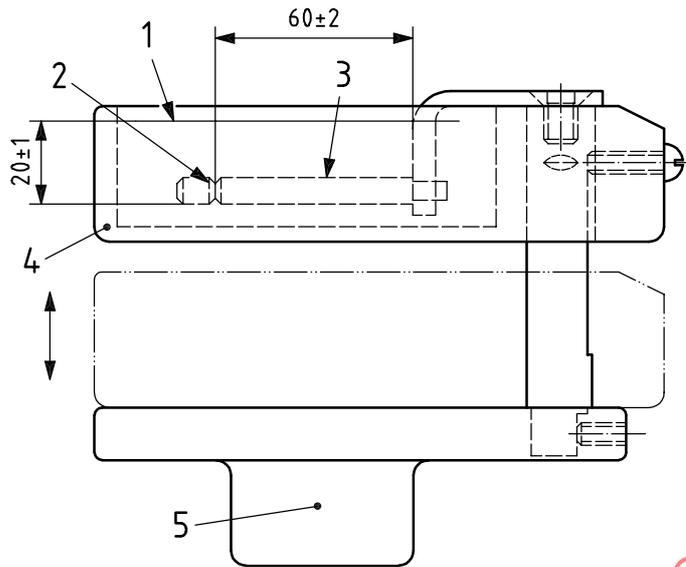
Figure 1 — Positioning of a test piece

5.1.3 Finch Cup soaking device

A Finch Cup soaking device (see Figure 2) consists of a support system that holds a horizontal cylindrical rod of $(5 \pm 0,4)$ mm diameter, and approximately 60 mm length, and a water container.

The water container shall be constructed such that it can be moved vertically and locked in a raised position. In the locked raised position, the water in the container shall completely surround the cylindrical rod, which is thereby immersed in the liquid to a depth of (20 ± 1) mm, as indicated in the example of Figure 2.

Projecting downwards, from the bottom of the device, is a rigid metal tongue by means of which the device can be held in the lower clamp of the tensile-strength-testing apparatus.



Key

- 1 liquid level mark
- 2 positioning groove
- 3 rod, $d (5 \pm 0,1)$ mm
- 4 water container (movable)
- 5 tongue

Figure 2 — Finch Cup soaking device (example)

5.2 Horizontal tensile-strength tester

5.2.1 Tensile-strength-testing apparatus

The tensile-strength-testing apparatus shall be in accordance with ISO 1924-2. It is capable of stretching a test piece of tissue paper or tissue product of given dimensions, at a constant rate of elongation of (50 ± 2) mm/min, and recording the tensile force as a function of elongation.

The force-measuring system shall measure loads with an accuracy of $\pm 1\%$ of the reading or $\pm 0,1$ N, whichever is the greater. It shall be calibrated and verified to confirm the requirements according to ISO 7500-1.

5.2.2 Tensile-tester clamps

The tensile-strength tester shall have two clamps for holding the test piece. Each clamp shall be designed to grip the test piece firmly along a straight line across the full width of the test piece, without causing any damage, and shall have means for adjusting the clamping force. The table between the clamps must be removable.

During the test, the clamping lines shall be parallel to each other within an angle of 1° . The clamping lines shall be perpendicular to the direction of the applied tensile force and to the longest dimension of the test piece, to the same level of accuracy.

The distance between the clamping lines, i.e. the test span, shall be adjustable to $(100,0 \pm 0,5)$ mm.

5.2.3 Soaking vessel

The soaking vessel can be inserted between the clamps of the tensile-strength tester (5.2.2), as shown in Figure 3.

The soaking vessel may be equipped with a device that, between the measurements, will adjust the water to a constant level.

5.3 Cutting device

The cutting device is capable of repeatedly cutting test pieces ($50,0 \pm 0,5$) mm wide and at least 150 mm in length, with undamaged, straight, smooth and parallel edges.

6 Conditioning

Condition the samples in a standard atmosphere at (23 ± 1) °C and (50 ± 2) % relative humidity according to ISO 187, unless otherwise agreed between the parties concerned.

7 Preparation

7.1 General

The sample shall be selected in accordance with ISO 186.

Condition the specimens in accordance with ISO 187 and keep them in the conditioning atmosphere throughout the test.

Handling of wet samples must be avoided.

7.1.1 Rapid ageing (curing)

The wet strength of tissue paper is frequently enhanced by addition of a wet strength agent. A rapid ageing with heat, also called curing, is frequently used to develop the maximum wet strength that a tissue paper or tissue product will achieve after a period of natural ageing at ambient conditions which may vary from a few days to several weeks, based on the wet strength agent used.

The decision of whether or not to use rapid ageing will be determined by the user of this part of ISO 12625, based upon the information about the tissue paper or tissue product sample being tested. Rapid ageing is not a requirement of this part of ISO 12625, but is an allowed option.

There is no rule for determining whether to rapid age or not, but the following principles are generally applied.

7.1.1.1 Production test pieces which have not left the manufacturing environment, are generally rapid aged. To rapid age a tissue paper or tissue product, it is recommended to heat in air at (80 ± 2) °C for 30 min. After heating, condition the test piece in a standard atmosphere at (23 ± 1) °C and (50 ± 2) % relative humidity for at least 1 h prior to testing.

For production inspections where data must be available quickly, rapid ageing conditions of (105 ± 2) °C for 15 min may be used.

7.1.1.2 Test pieces which have been delivered into the marketing chain, and especially those available for sale to the ultimate consumer, are generally not aged.

It must be understood that the wet strength of test pieces after rapid ageing may be different than that which will be experienced by the end user of the product.

The test report shall state whether the test piece was or was not rapid aged, and if so, by what procedure.

7.2 Dimensions

7.2.1 Vertical tester

Each test piece shall be $(50,0 \pm 0,5)$ mm in width and at least 150 mm in length, avoiding perforations and faults. For finished tissue product items of very short dimensions, cut the longest test piece possible, and reduce the distance between the top edge of the rod of the Finch Cup soaking device and the bottom edge of the upper clamp of the tensile-strength-testing apparatus from $(43,5 \pm 1)$ mm to $(23,5 \pm 1)$ mm.

7.2.2 Horizontal tester

Cut test pieces of $(50,0 \pm 0,5)$ mm width and preferably approx. 150 mm length, avoiding perforations and faults.

If the specimens are so small that test pieces of 150 mm length cannot be obtained, cut test pieces as long as the specimens allow and, when testing these test pieces, use the maximum test span that can be used with secure clamping. Report the test span.

7.3 Number of test pieces

Cut one test piece from each of ten specimens in the machine direction and from ten specimens in the cross direction. Should, in isolated cases, the requisite number of 2×10 specimens not be available, test at least ten test pieces in each direction equally distributed across the available specimens.

8 Procedure

8.1 Calibration and adjustment of the tester

Ensure that the tensile-strength tester is level and is calibrated as recommended by the manufacturer and in accordance to ISO 7500-1.

Check that the clamps are aligned to meet the requirements in 5.2.2. Position the clamps such that the test span is $(100,0 \pm 0,5)$ mm. Adjust the rate of elongation (the rate of separation of the clamps) to (50 ± 2) mm/min. Adjust the clamping force in such a way that the test piece does not slip or suffer damage during the test.

8.2 Vertical test method

8.2.1 Mounting the Finch Cup soaking device

With the rod of the Finch Cup soaking device in a horizontal position, clamp the Finch Cup soaking device with its rigid tongue projecting from the bottom of the device in the lower clamp of the tensile-strength-testing apparatus.

Pre-set the distance between the top edge of the rod of the Finch Cup soaking device and the bottom edge of the upper clamp of the tensile-strength-testing apparatus at $(43,5 \pm 1)$ mm. In this case, the total test span length of a dry test piece looped under the rod will be (100 ± 2) mm. Half this distance is regarded as the test span length. In the case of very short specimens, this distance may be reduced to $(23,5 \pm 1)$ mm (see 7.2.1).

8.2.2 Measurement

8.2.2.1 Wet tensile strength

Place the water container in its bottom position and fill it up to the mark with distilled or deionized water at $(23 \pm 1)^\circ\text{C}$. Insert the dry test piece horizontally under the dry rod, bend it around the rod creating a loop and clamp the tow ends of the test piece in the upper clamp of the tensile-strength-testing apparatus as shown in Figure 1. Ensure that both ends of the looped test piece are held by the clamp, tightened without causing damage, while avoiding slippage during the test.

Raise the water container until it locks in its upper position, thereby immersing the looped end of the test piece to a depth of at least 20 mm below the initial water level.

Immediately start a stop watch.

After soaking for 15 s, lower the water container to its lowest position. Then immediately initiate the tensile test. Determine the wet tensile strength of the immersed test piece at an elongation rate of (50 ± 2) mm/min.

Divide the recorded wet tensile force by 2, to obtain the wet tensile force of the single test piece.

If the test piece breaks on the rod of the Finch Cup soaking device or in the upper clamp, reject the readings of the test and repeat with additional test pieces.

After the test, wipe dry the horizontal rod of the Finch Cup soaking device, before attaching the next test piece. After each test, top up the water container with distilled or deionized water. After each set of samples, clean and refill the water container.

8.2.2.2 Wet-tensile-strength retention

If the wet-tensile-strength retention is to be determined, remove the water from the soaking cup and measure the tensile strength with the Finch Cup soaking device.

8.3 Horizontal test method

8.3.1 Measurement

8.3.1.1 Wet tensile strength

Remove the table between the clamps of the tensile-strength tester (5.2.2) and place the soaking vessel (5.2.3) between the clamps. Fill the soaking vessel with distilled or deionized water at $(23 \pm 1)^\circ\text{C}$.

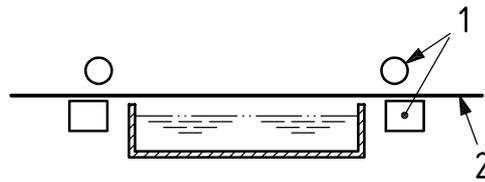
For tensile-strength testers in which the soaking procedure is accomplished manually, place a test piece in the testing position, as shown in Figure 3. Push the ends of the test piece towards each other so that the middle region of the test piece dips into the water in the soaking vessel as in Figure 4. Allow the test piece to soak in the soaking vessel for 15 s.

Gently pull the ends of the test piece away from each other, so that the test piece is lifted from the soaking bath. Place the test piece in its original position and clamp the test piece, as indicated in Figure 5. Start the wet-tensile-strength testing. Record the wet tensile force, F , in newtons.

If the soaking procedure is accomplished automatically, set the soaking time to 15 s, insert the test piece as indicated in Figure 3, clamp the test piece and follow the instructions given by the manufacturer of the tester. Record the wet tensile force, F , in newtons.

Reject results from any test pieces that break within 2 mm of the clamping line. Change the water after each set of 10 test pieces.

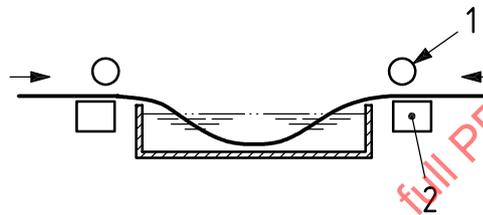
NOTE If the volume of the soaking vessel is sufficiently small, such that the water has been successively renewed during the test series, it is not necessary to change the water after each set of 10 test pieces.



Key

- 1 clamps
- 2 test piece

Figure 3 — The two clamps, the soaking vessel filled with water, and the test piece inserted between the two clamps

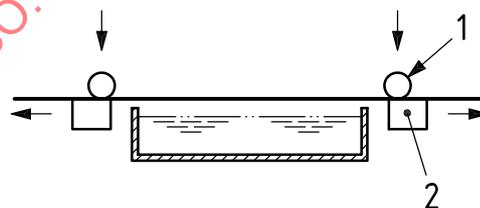


Key

- 1 upper clamp
- 2 lower clamp

The ends of the test piece are pushed towards each other so that the middle of the test piece is dipped into the soaking vessel (in the automatic soaking procedure the clamps are closed).

Figure 4 — Immersion of test piece in the water



Key

- 1 upper clamp
- 2 lower clamp

Figure 5 — The wet test piece is clamped and the wet-tensile-strength testing is started

8.3.1.2 Wet-tensile-strength retention

If the wet-tensile-strength retention is to be determined, remove the soaking vessel and replace it with the table. Measure the tensile strength of the dry conditioned test pieces as described in ISO 12625-4.

9 Calculation

Calculate and report the results separately for the machine and cross directions.

9.1 Wet tensile strength

Calculate the mean maximum tensile force \bar{F} of the wet test pieces, in newtons, and then the mean wet tensile strength from Equation (1):

$$\bar{S} = \frac{\bar{F}}{w_i} \times 10^3 \quad (1)$$

where

\bar{S} is the mean wet tensile strength, in newtons per metre;

\bar{F} is the mean maximum tensile force, in newtons;

w_i is the initial width, in millimetres, of the test piece (standard 50 mm).

Report the mean wet tensile strength of the test pieces, in newtons per metre, to three significant figures.

9.2 Wet-tensile-strength retention

Calculate the mean wet-tensile-strength retention from Equation (2):

$$\bar{S}_R = \frac{100 \times \bar{S}}{\bar{S}_D} \quad (2)$$

where

\bar{S}_R is the mean tensile strength retention, as a percentage;

\bar{S} is the mean wet tensile strength, in newtons per metre;

\bar{S}_D is the mean tensile strength of the test piece in the dry conditioned state, in newtons per metre.

Report the wet-tensile-strength retention of the test pieces, as a percentage, to one significant figure.

10 Test report

The test report shall include the following information:

- a reference to this part of ISO 12625;
- date and place of testing;
- conditions;
- description and identification of the sample (for example, product category, date and place of sampling);
- if not ten values, the number of single values used to calculate the means of wet tensile strength;

- f) the wet tensile strength, in newtons per metre (wet), in the machine and cross directions, rounded to
 - 0,1 for loads up to 100 N/m, recorded to the nearest one decimal place,
 - 1 for loads over 100 N/m, recorded to the nearest whole number;
- g) standard deviation or coefficient of variation;
- h) if required, wet-tensile-strength retention as a percentage;
- i) whether the test piece was rapid aged, and under what conditions;
- j) any departure from this part of ISO 12625 and any other circumstances that may have affected the test results.

11 Precision

11.1 General

In an interlaboratory study, 11 laboratories tested 5 tissue samples in machine and cross directions according to this standard. 5 laboratories used vertical testers with a Finch Cup soaking device and 6 laboratories used horizontal testers equipped with a soaking vessel. Statistical calculation has shown that there are no significant differences in the results between the two types of apparatus. In Tables 1 to 3, the results for the vertical and horizontal tests are pooled together.

11.2 Wet tensile strength

Table 1 — Results of an interlaboratory test

Sample	Mean wet tensile strength	Standard deviation between laboratories	Reproducibility coefficient of variation	Reproducibility limit ^a
	N/m	s N/m	%	R N/m
B1, CD	19,0	2,4	12,4	7,5
D1, CD	35,3	2,4	6,8	7,7
A1, CD	66,8	3,3	4,9	10,6
B1, MD	41,7	3,3	7,8	10,5
E1, CD	84,9	6,7	7,9	21,5
E2, CD	89,8	4,2	4,7	13,5
A1, MD	148	5,4	3,7	17,4
D1, MD	85,7	6,1	7,1	19,6
E2, MD	168	7,5	4,4	23,9
E1, MD	182	9,2	5,0	29,3

MD: machine direction
 CD: cross direction

^a Agreement expected with 95 % probability, $R = 1,96\sqrt{2} \times s$.